UNIVERSIDADE DO VALE DO ITAJAÍ
ENGENHARIA DE COMPUTAÇÃO
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CIRCUITOS ELETRÔNICA BÁSICA – M1

Relatório apresentado como requisito parcial para a obtenção da M1 da disciplina de Eletrônica básica do curso de Engenharia de Computação pela Universidade do Vale do Itajaí da Escola do Mar, Ciência e Tecnologia.

Prof. Walter Antonio Gontijo

Itajaí
2021

1. OBJETIVO

2. INTRODUÇÃO

3. CIRCUITOS

3.1 – REVISÃO DE ANÁLISE DE CIRCUITOS ELÉTRICOS

3.1.1- RESISTÊNCIA EQUIVALENTE

Encontre a resistência equivalente dos circuitos abaixo:

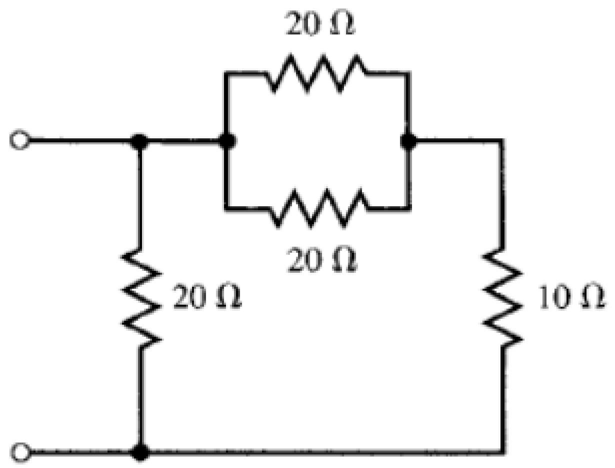


Figura 1 - Circuito 3.1.1 proposto

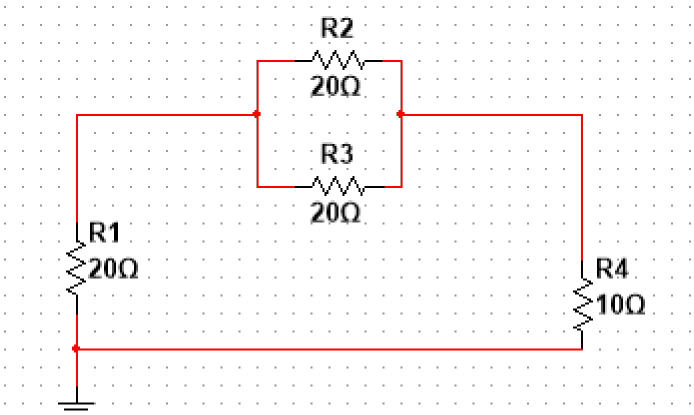


Figura 2 - Circuito 3.1.1 simulado no Multisim

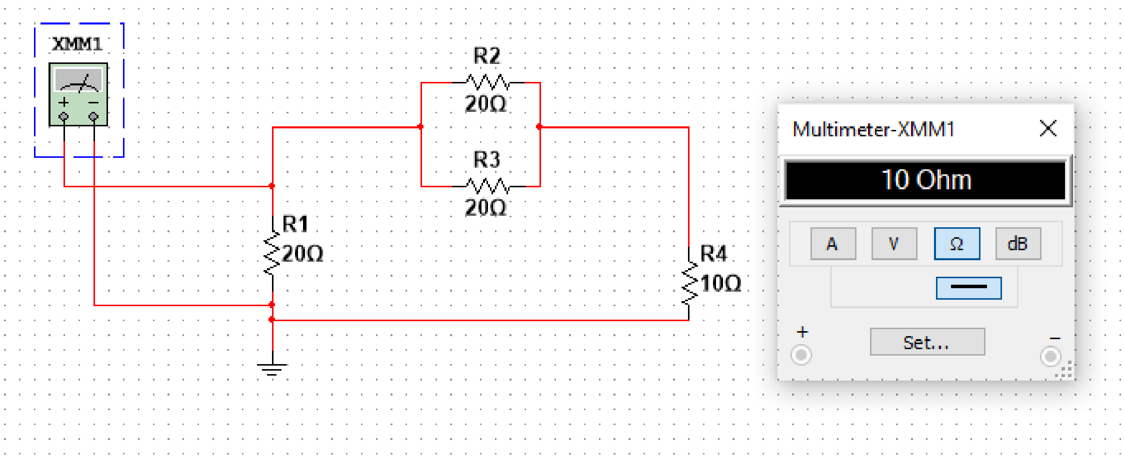


Figura 3 - Resistência equivalente do circuito 3.1.1 mensurada no Multisim

CÁLCULOS

20 Ω || 20 Ω + 10 = $\frac{20*20}{20+20} = \frac{400}{40} = 10\ \Omega$

TABELA COMPARATIVA

PARÂMETRO	SIMULADO	TEÓRICO
Resistência equivalente	10 Ω	10 Ω

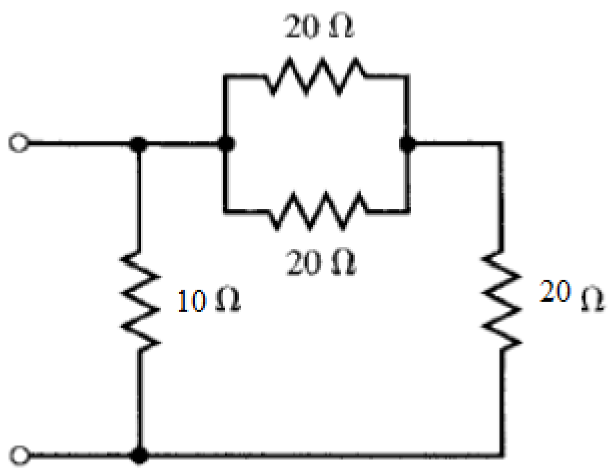


Figura 4 - Circuito 3.1.2 proposto

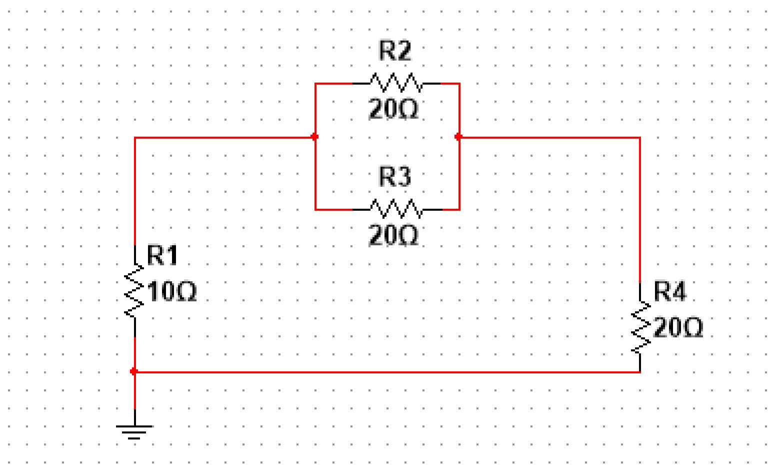


Figura 5 - Circuito 3.1.2 simulado

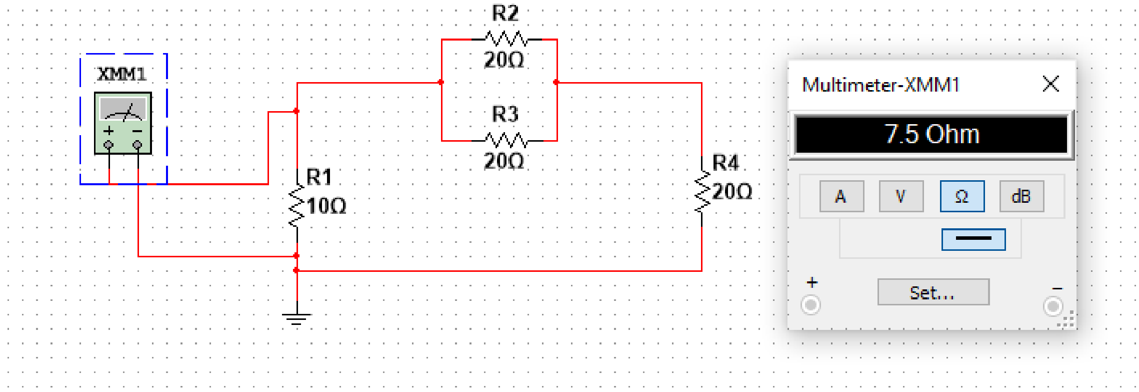


Figura 6 - Resistência equivalente do circuito 3.1.2 mensurada

CÁLCULOS

$$(20\ \Omega\ ||\ 20\ \Omega + 20\ \Omega) = \frac{20*20}{20+20} = \frac{400}{40} = 10\ \Omega + 20\ \Omega$$

$$30\ \Omega\ ||\ 10\ \Omega = 7{,}5\ \Omega$$

TABELA COMPARATIVA

PARÂMETRO	SIMULADO	TEÓRICO
Resistência equivalente	7,5 Ω	7,5 Ω

3.1.3 - MALHA SIMPLES

Encontre V3 e sua polaridade levando em conta que a corrente I no circuito é de 0,40 A.

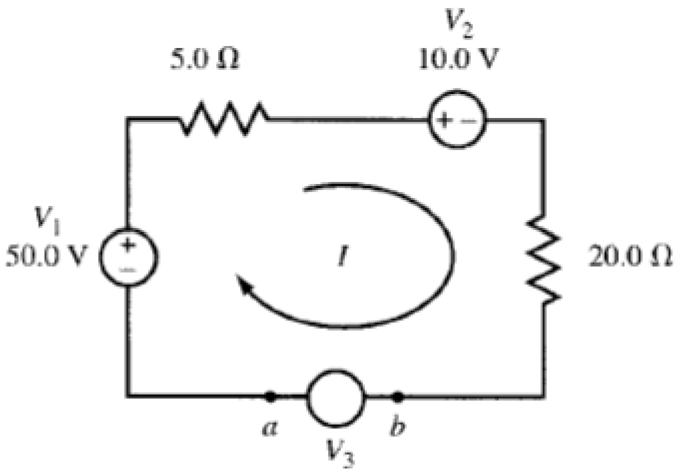


Figura 7 - Circuito 3.1.3 proposto

CÁLCULOS

Req = 20 Ω + 5 Ω = 25 Ω

- 50V + 25i + 10 V = 0

- 40 V = -25 i

$$i = \frac{40}{25} = 1{,}6\ A$$

V = R * I

Vab = 25 * 0,4 A

Vab = 10 V

Vx = 25 * 1,6 A

Vx = 40 V

V3 = Vx – Vab

V3 = 30 V

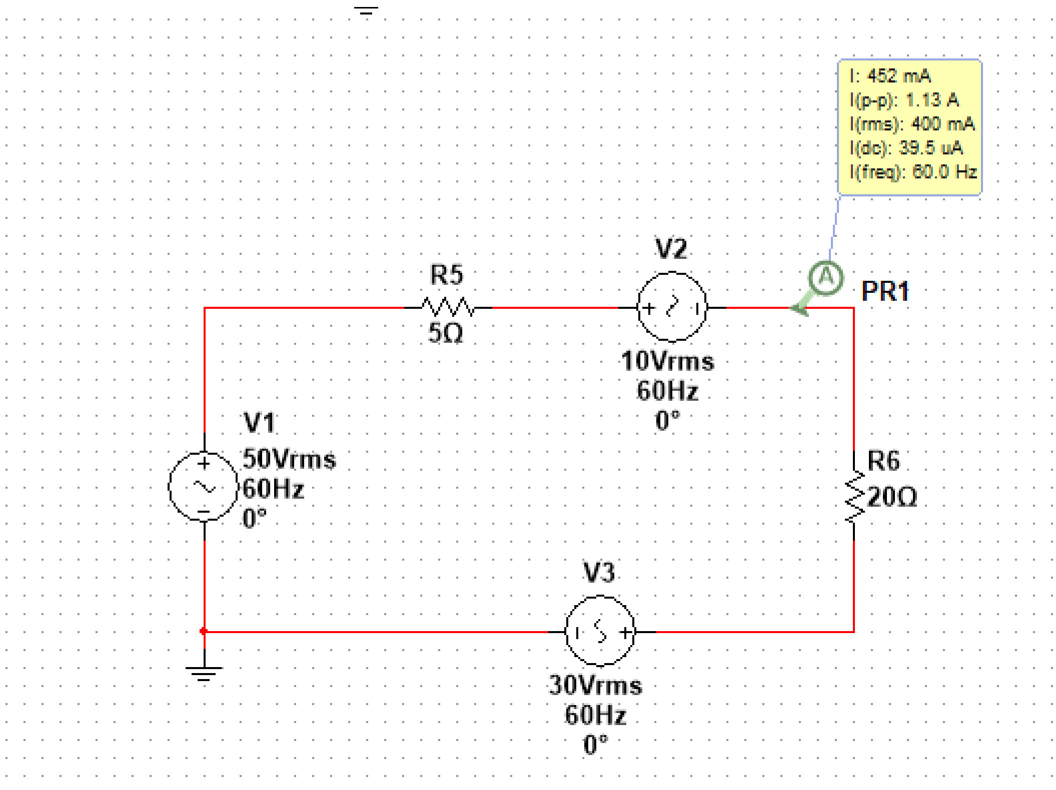


Figura 8 - Circuito 3.1.3 simulado

TABELA COMPARATIVA

PARÂMETRO	SIMULADO	TEÓRICO
Corrente no circuito	0,4 A	0,4 A
V3	30 V	30 V

3.1.14 – MALHAS

Encontre os valores de corrente no circuito a seguir:

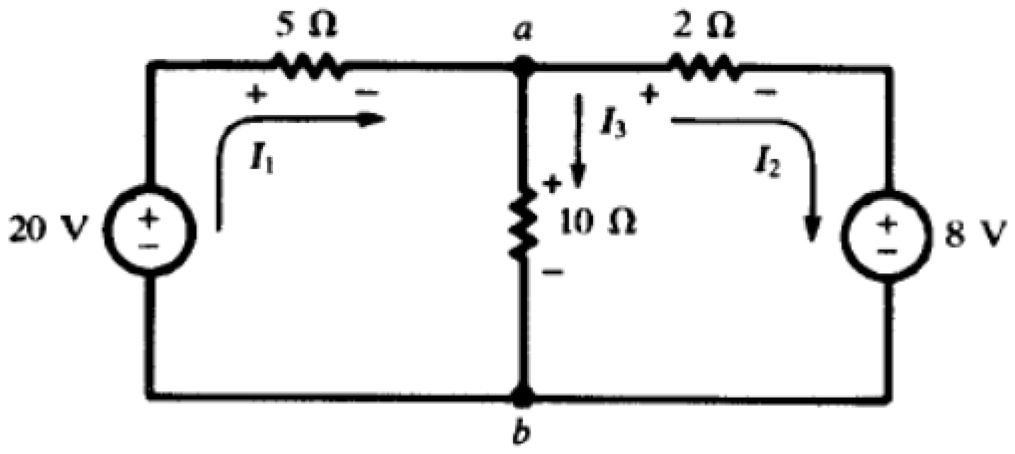


Figura 9 - Circuito 3.1.4 proposto

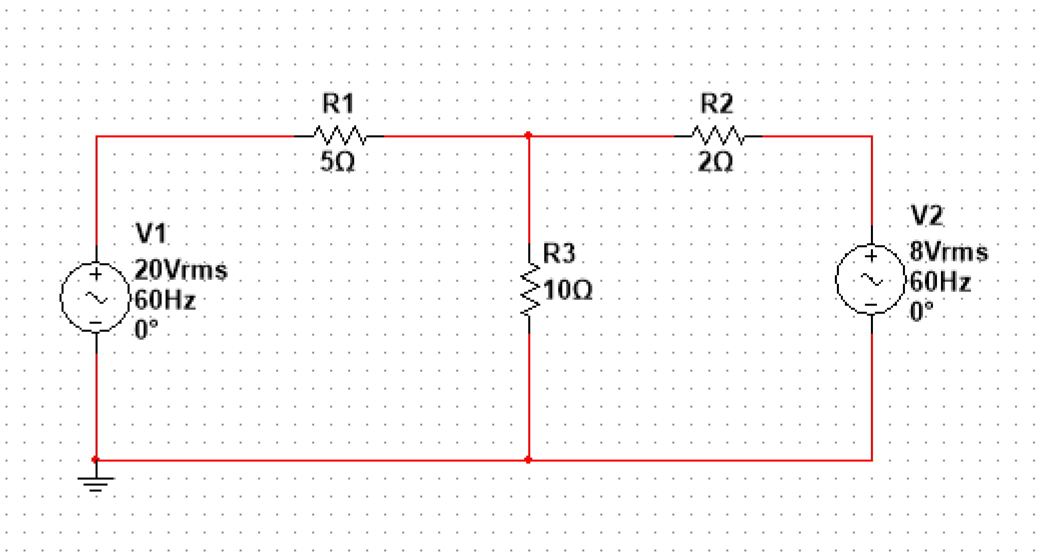


Figura 10 - Circuito 3.1.4 simulado

CÁLCULOS

Malha 1:

-20V + 5i1 + 10 (i1 - i2) = 0

5i1 + 10i1 - 10i2 = 20

15 i1 - 10i2 = 20

Malha 2:

8V – 10 (i1-12) + 2i2 = 0

-10i1 + 10i2 + 2i2 = -8V

$$\begin{cases} 15i1 - 10i2 = 20\ (*\ 12) \\ -10i1 + 10i2 + 2i2 = \ -8\ (*\ 10) \end{cases}$$

$$\begin{cases} 180i1 - 120\ i2 = 240 \\ -100i1 + 100i2 + 20\ i2 = \ -80 \end{cases}$$

180i1 – 100i1 – 120i2 + 120 i2 = 240 -80

80i1 = 160

I1 = 2 A

Substituindo em malha 1:

15 * 2 – 10i2 = 20

30 – 10i2 = 20

-10i2 = -10

I2 = 1 A

I3 = I1 – I2

I3 = 2 – 1

I3 = 1 A

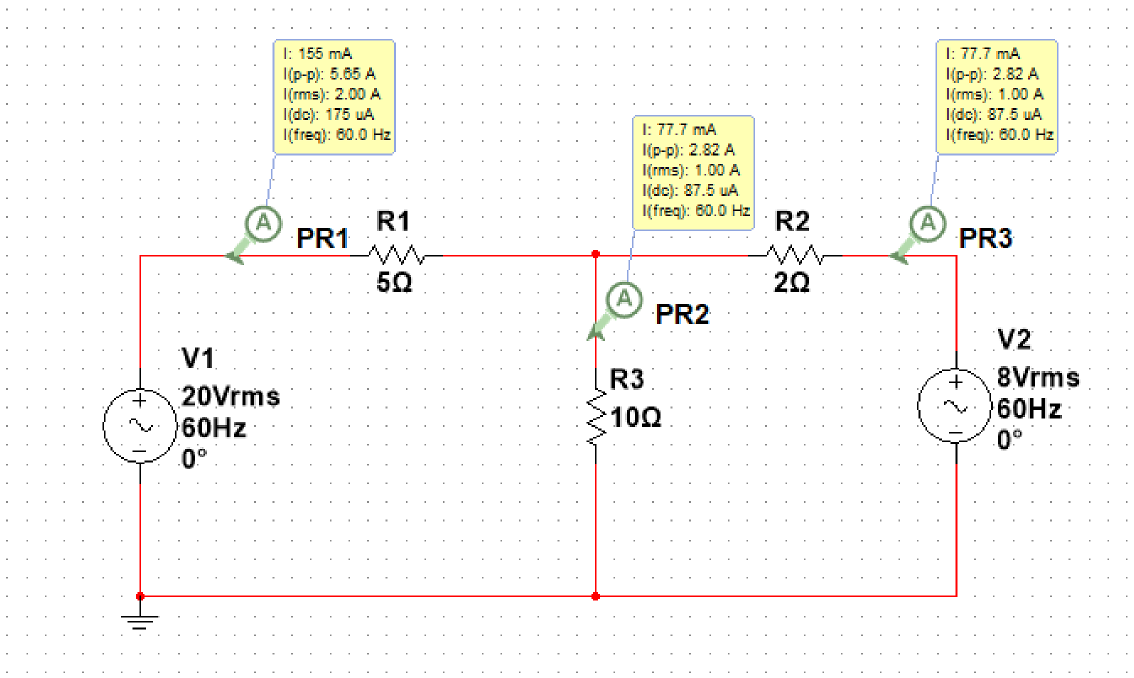


Figura 11 - Mensuração no circuito 3.1.4

TABELA COMPARATIVA

PARÂMETRO	SIMULADO	TEÓRICO
I1	2 A	2 A
I2	1 A	1 A
I3	1 A	1 A

3.1.5 - SUPERPOSIÇÃO

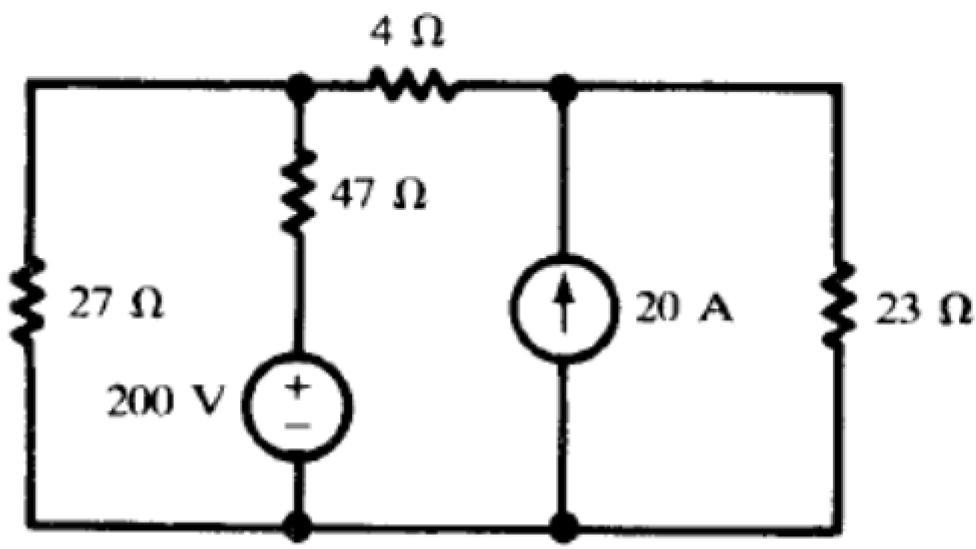
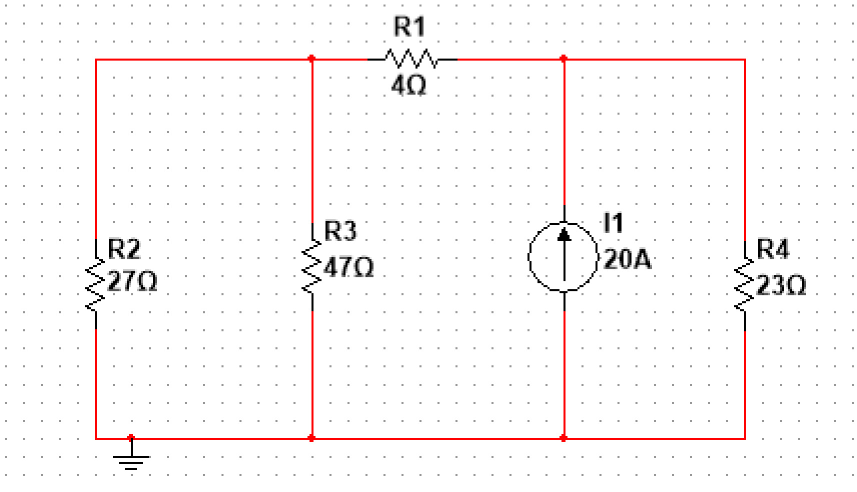


Figura 12 - Circuito 3.1.5 proposto

CÁLCULOS

V1 inativo e V2 ativo:



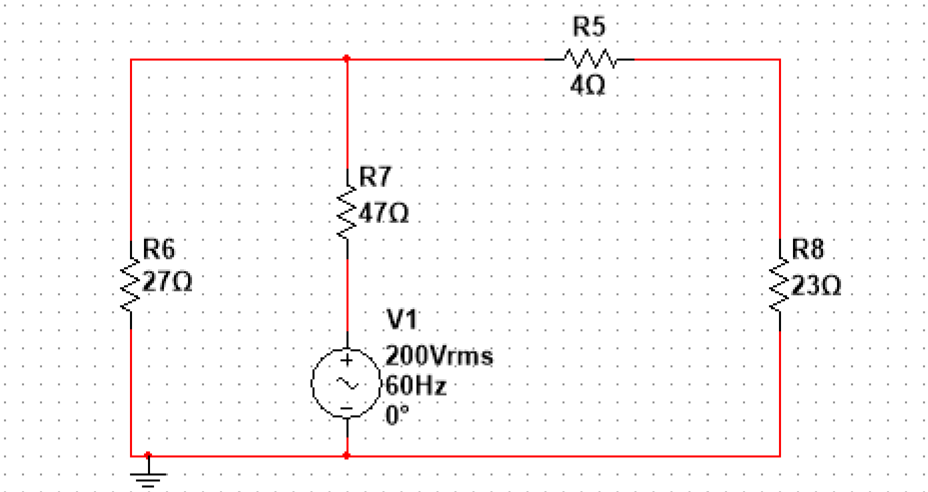
Req = (27||47) + 4 = $\frac{27*47}{27+47} + 4 = 21{,}15\ \Omega$

Req = (21,15 || 23) = $\frac{21{,}15*23}{21{,}15+23}$ = 11,02 Ω

Ix = $\frac{20*23}{44{,}15} = -10{,}42\ A$

V1 = $4*(-10{,}42) = -41{,}68\ V$

V1 ativo V2 inativo:



Req = (27||27) + 47 = $\frac{27*27}{27+27} + 47 = 13{,}5 + 47 = 60{,}5\ \Omega$

I = $\frac{200}{60{,}5} = 3{,}31\ A$

Ix = $\frac{27*3{,}31}{27+27} = \frac{89{,}37}{54} = 1{,}65\ A$

V2 = $4*1{,}65 = 6{,}62$

Vx = 6,62 + (-41,68) = -35,06 V

Vx = 35,06 V

3.1.6 - THÉVENIN E NORTON

Calcule o equivalente de Thévenin e o equivalente de Norton para o circuito a seguir:

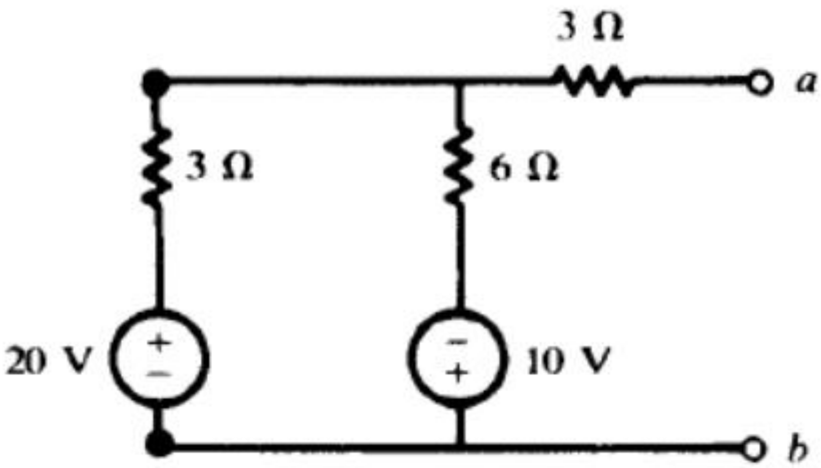


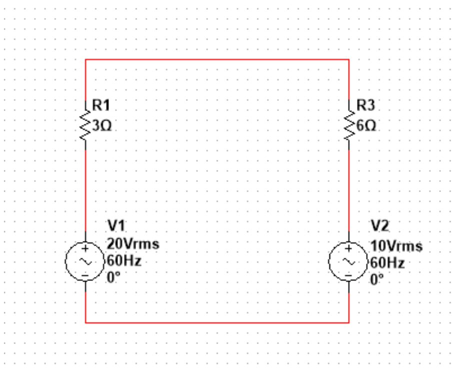
Figura 13 - Circuito 3.1.6 proposto

CÁLCULOS

Thévenin:

Rth = 6 || 3 = $\frac{6*3}{9} = 2\ \Omega$

Rth = 2 + 3 $= 5\ \Omega$



3i + 6i – 10 V – 20 V = 0

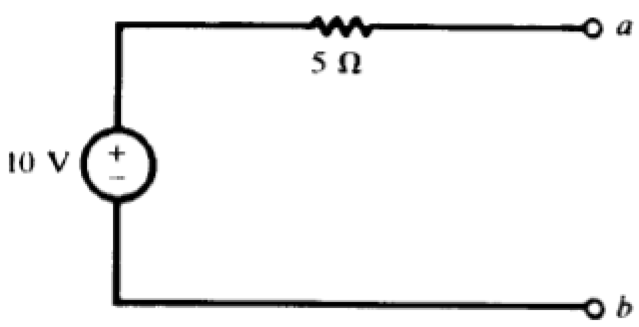
9i = 30 V

I = 3,33 A

Vth = R3 * I + V2

Vth = 6 * 3,33 – 10

Vth = 9, 98 V



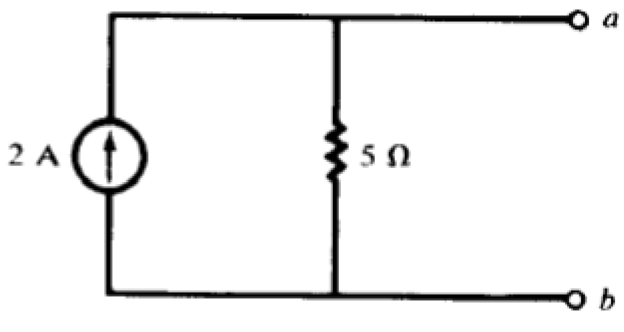
Norton:

Rth = Rn

Rn = 5 Ω

In = $\frac{Vth}{Rth} = \frac{9{,}98}{5}$

In = 2 A



(*b*) Norton Equivalent

3.2 – DIODOS

3.2.1 – DIODO IDEAL

Calcule ID, IR, VD e VR, para E = 11V. Considere o diodo ideal.

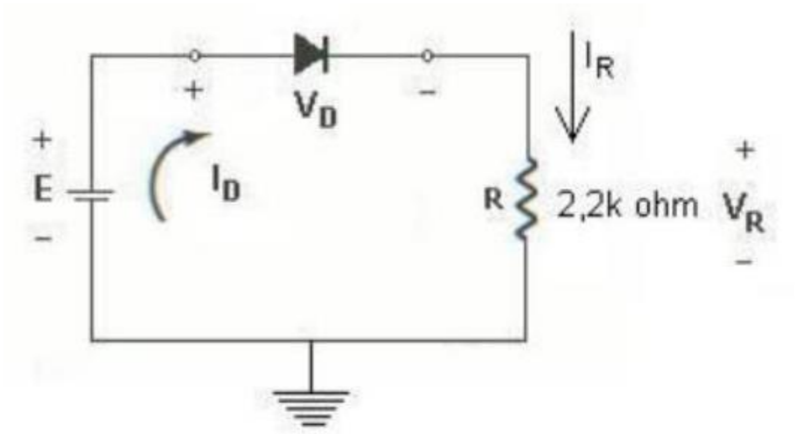


Figura 14 - Circuito 3.2.1 proposto

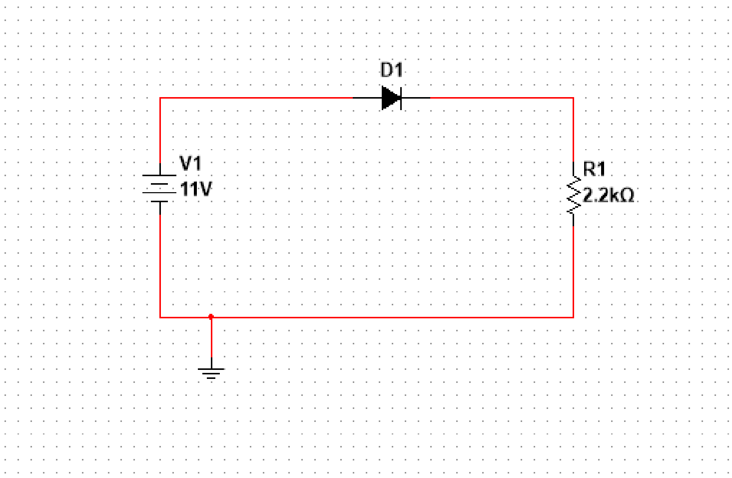


Figura 15 - Circuito 3.2.1 simulado

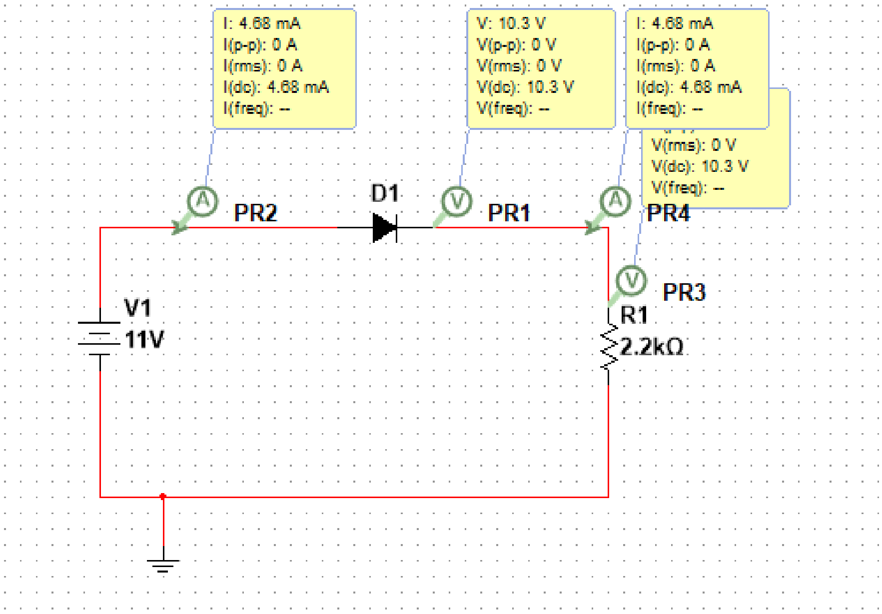


Figura 16 - Mensuração circuito 3.2.1

TABELA COMPARATIVA

PARÂMETRO	SIMULADO	TEÓRICO
ID	4,68 mA	5 mA
IR	4,68 mA	5 mA
VD	10,3 V	10 V
VR	10,3 V	10 V

CÁLCULOS

$$E - vD - i * R = 0$$

$$E = Vd + i * R$$

$$I = \frac{11V}{2{,}2k\Omega} = 0{,}005 = 5\ mA$$

$$11 = VD + 0{,}005 * 2{,}2k$$

$$VD = 11 - 0{,}005 * 2{,}2k$$

$$VD = 11 - 1{,}1$$

$$VD = 9{,}9\ V$$

$$VD = VR$$

$$VR = 10\ V$$

Repita o exercício anterior considerando que a polaridade da fonte E foi invertida.

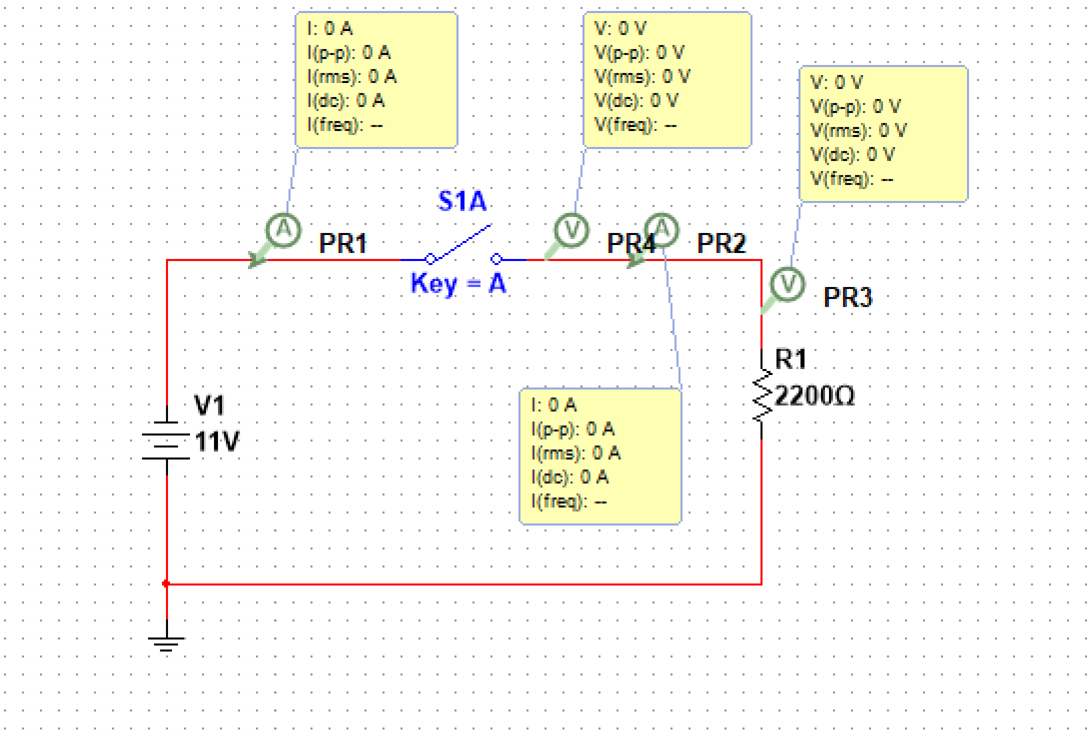


Figura 17 - Circuito 3.2.1 com a fonte invertida polarmente

3.2.2 – DIODO IDEAL

Calcule ID, Vo e VD2. Considere diodo ideal.

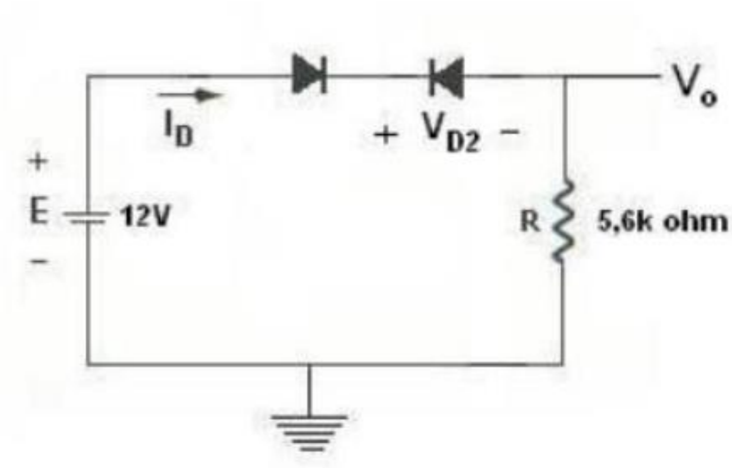


Figura 18 - Circuito 3.2.2 proposto

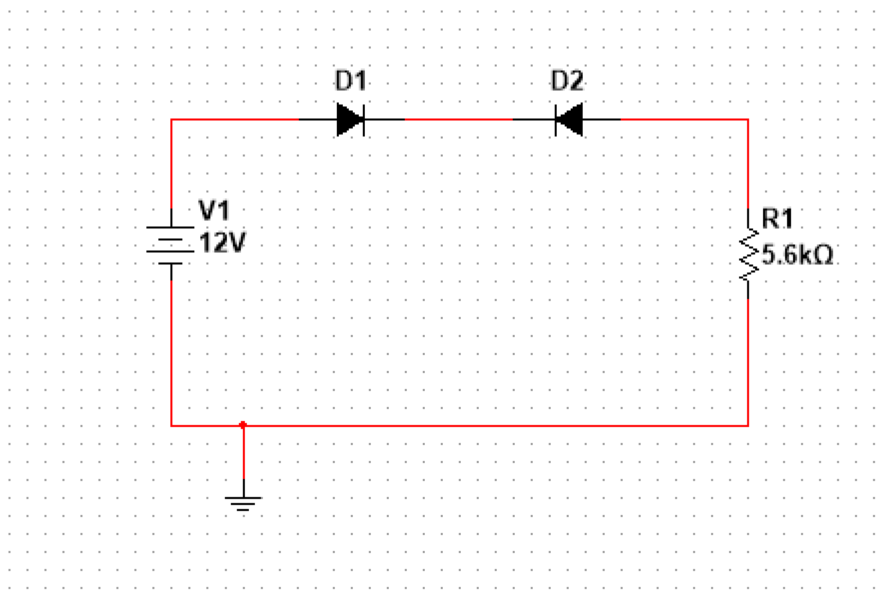


Figura 19 - Circuito 3.2.2 simulado

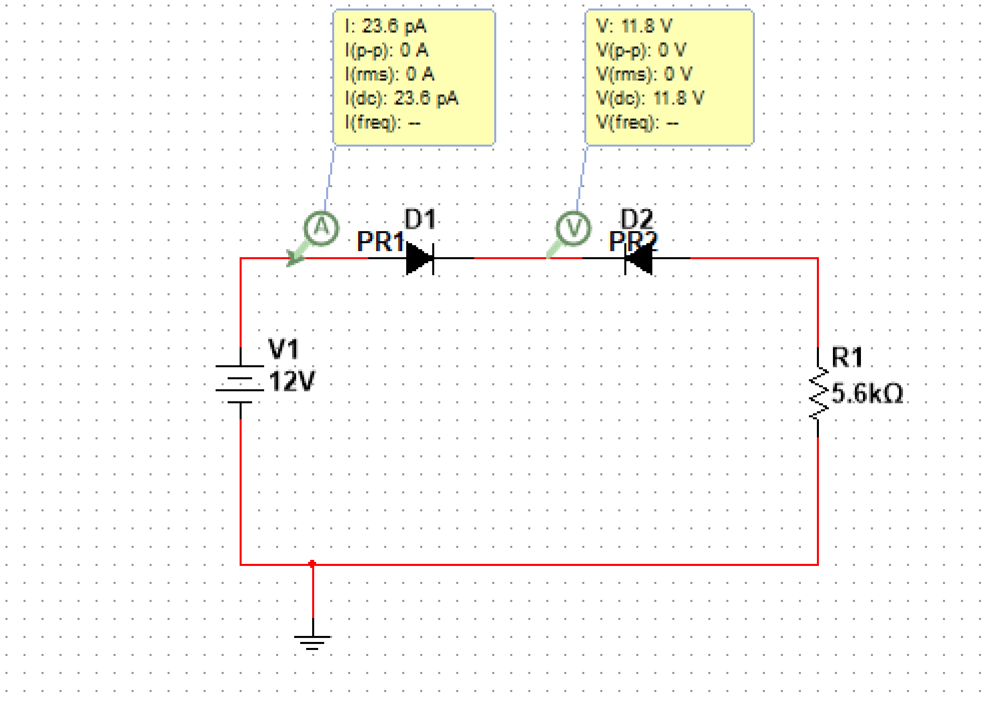


Figura 20 - Circuito 3.2.2 mensurado

CÁLCULOS

$$Id = \frac{12}{5{,}6k}$$

$$Id = 0{,}002143\ A = 0{,}214\ mA$$

$$V0 = 0$$

$$Vd2 = 12V$$

TABELA COMPARATIVA

PARÂMETRO	SIMULADO	TEÓRICO
ID	0,0023 A	0,0021 A
V0	0	0
VD2	11,8 V	12 V

3.2.3 – DIODO IDEAL

Calcule I, VA, VR e Vo. Considere diodo ideal.

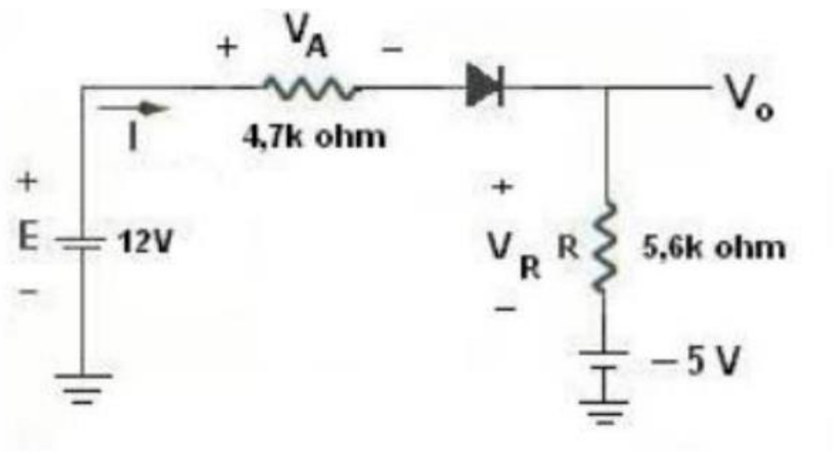


Figura 21 - Circuito 3.2.3 proposto

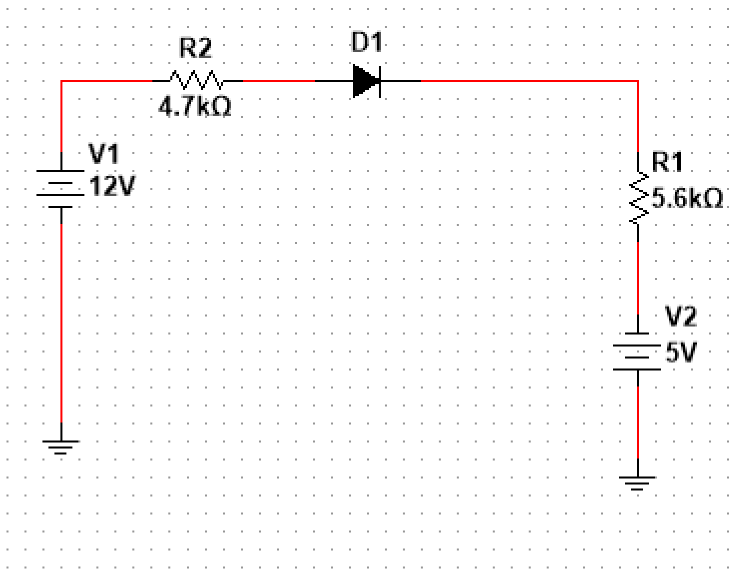


Figura 22 - Circuito 3.2.3 simulado

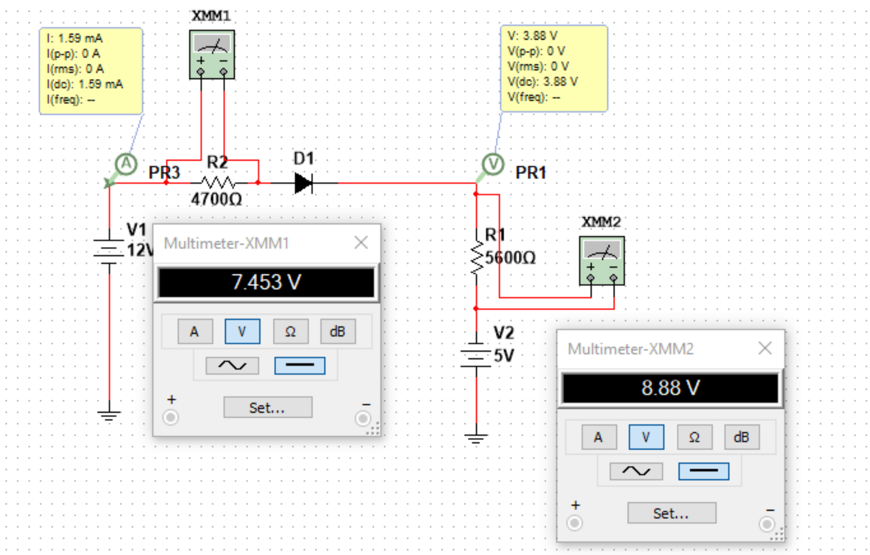


Figura 23 - Circuito 3.2.3 mensurado

CÁLCULOS

$$I = \frac{12+5}{4,7\,k + 5,6\,k} = \frac{17}{10,3k} = 0,0016A = 1,6\,mA$$

$$VA = R * i = 4,7k * 0,0016 = 7,52\,V$$

$$VR = 5,6\,K * 0,0016 = 8,96\,V$$

$$v0 = 10,3k * 0,0016 = 16,48\,V$$

TABELA COMPARATIVA

PARÂMETRO	SIMULADO	TEÓRICO
I	1,59 mA	1,6 mA
VA	7,453 V	7,52 V
VR	8,8 V	8,96 V
V0		

3.2.4 – FORMA DE ONDA

Obtenha a forma de onda Vo para a entrada mostrada. Considere diodo ideal

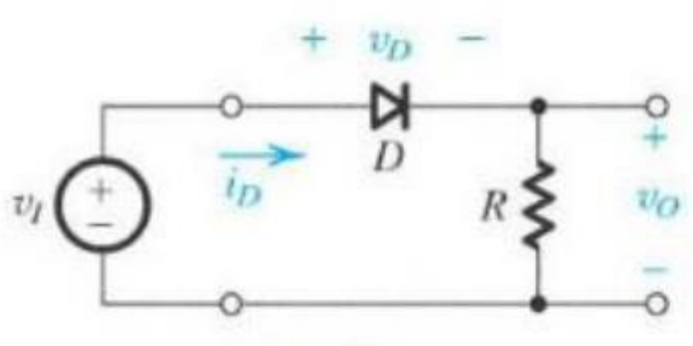


Figura 24 - Circuito 3.2.4 proposto

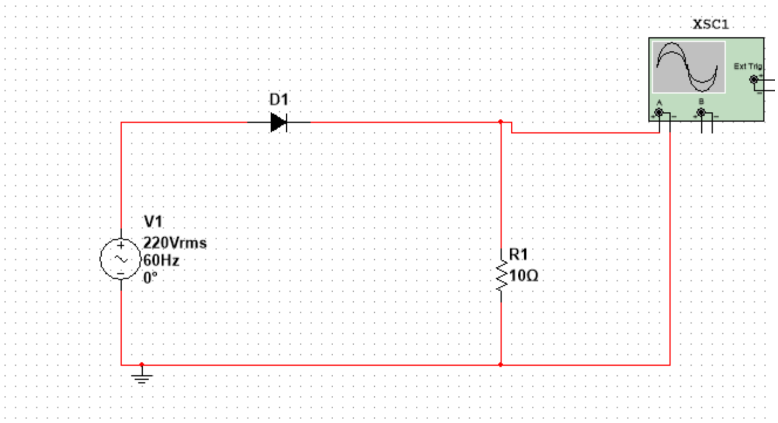


Figura 25 - Circuito 3.2.4 simulado

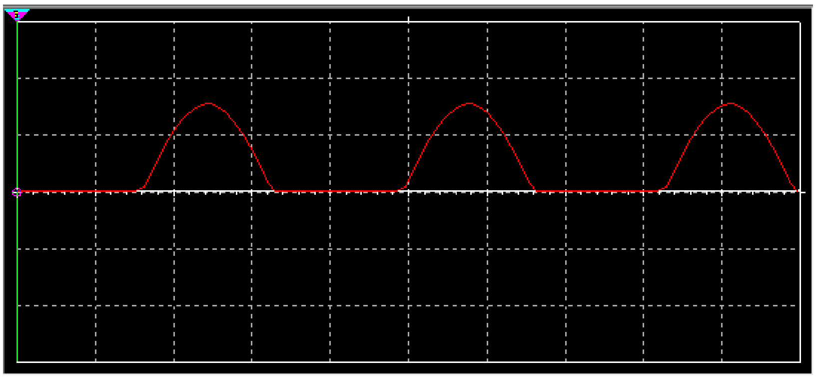


Figura 26 - Circuito 3.2.4 forma de onda

3.2.5 – FORMA DE ONDA CHAVE ABERTA E FECHADA

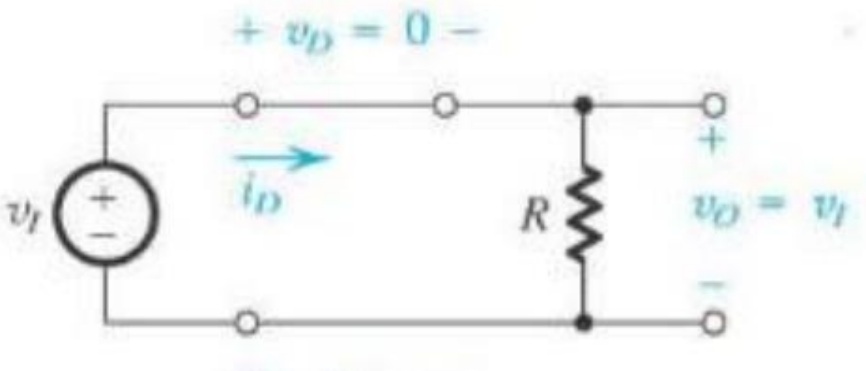


Figura 27 - Circuito 3.2.5-1 proposto

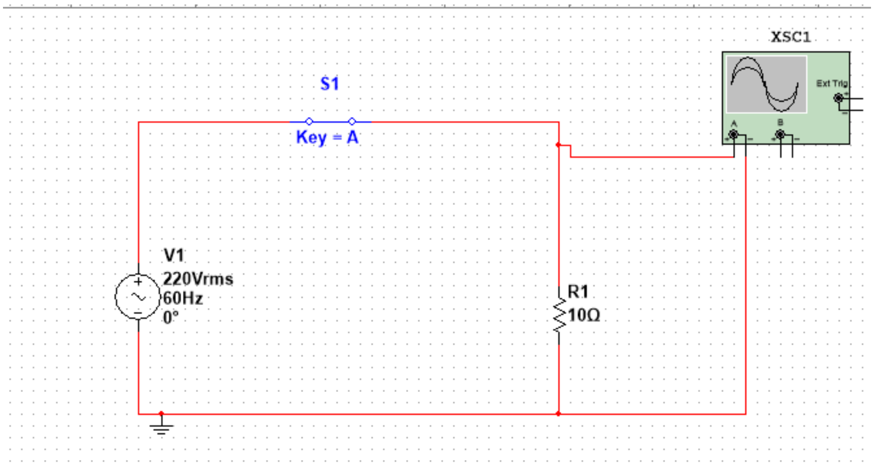


Figura 28 - Circuito 3.2.5 -1 simulado

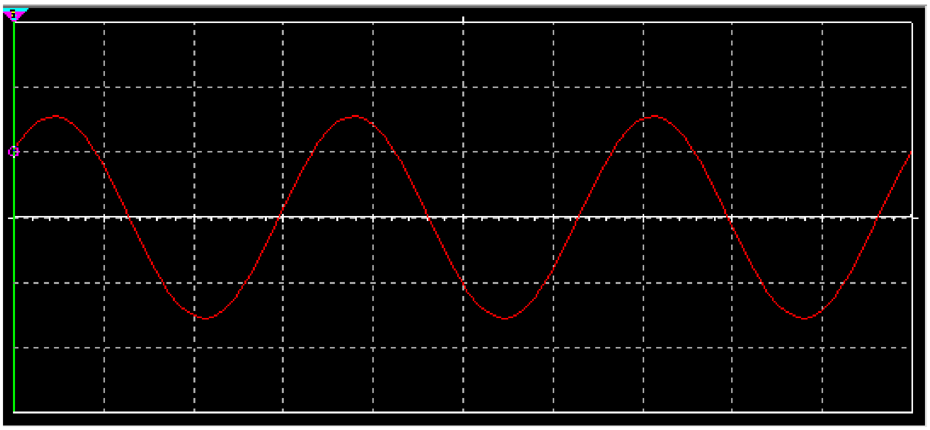


Figura 29 - Circuito 3.2.5-1 forma de onda

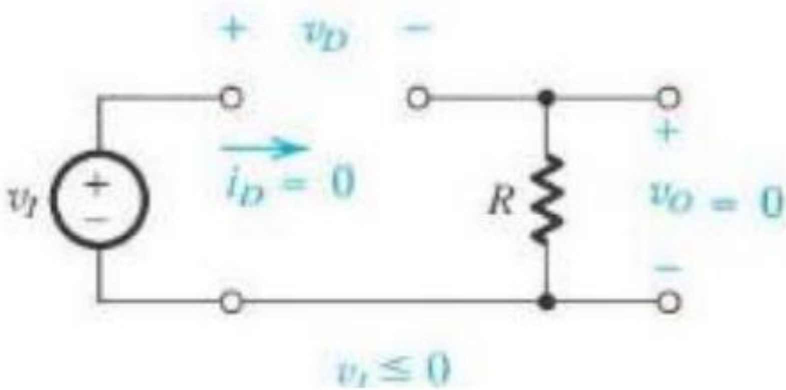


Figura 30 - Circuito 3.2.5-2

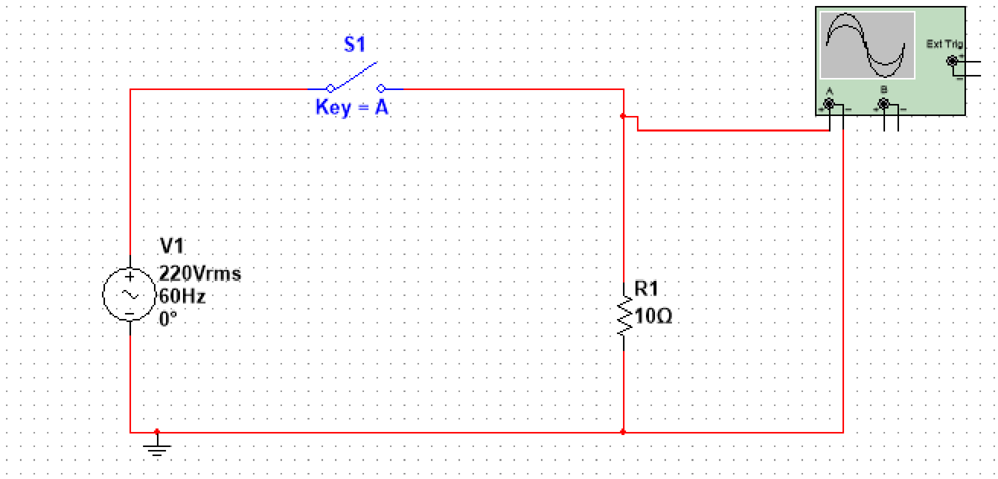


Figura 31 - Circuito 3.2.5 - 2 simulado

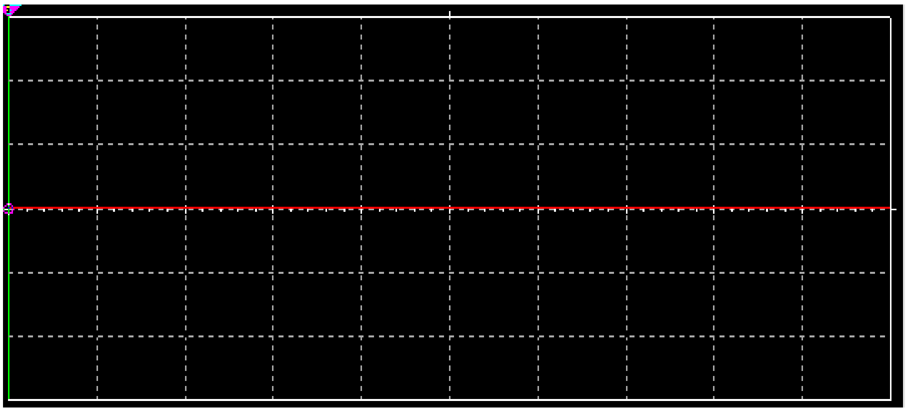


Figura 32 - Circuito 3.2.5-2 forma de onda

3.2.6 – DC SWEEP

Gerar a curva de um ou mais diodos utilizando a ferramenta DC Sweep do software Multisim.

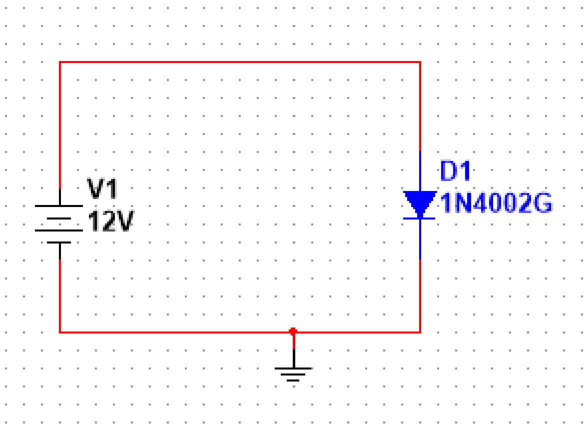


Figura 33 - Diodo número 1

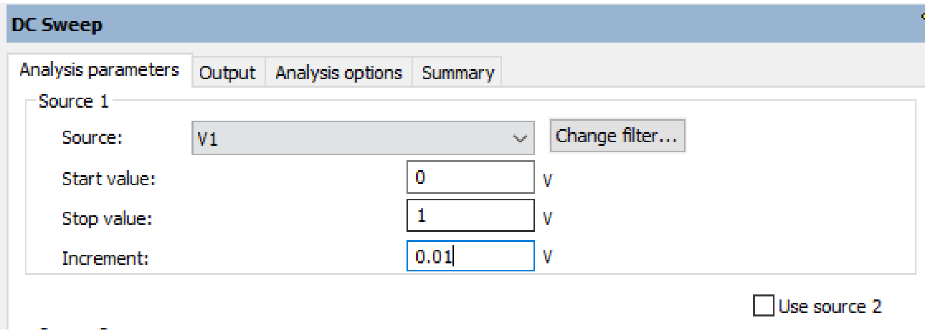


Figura 34 - Configurações DC Sweep

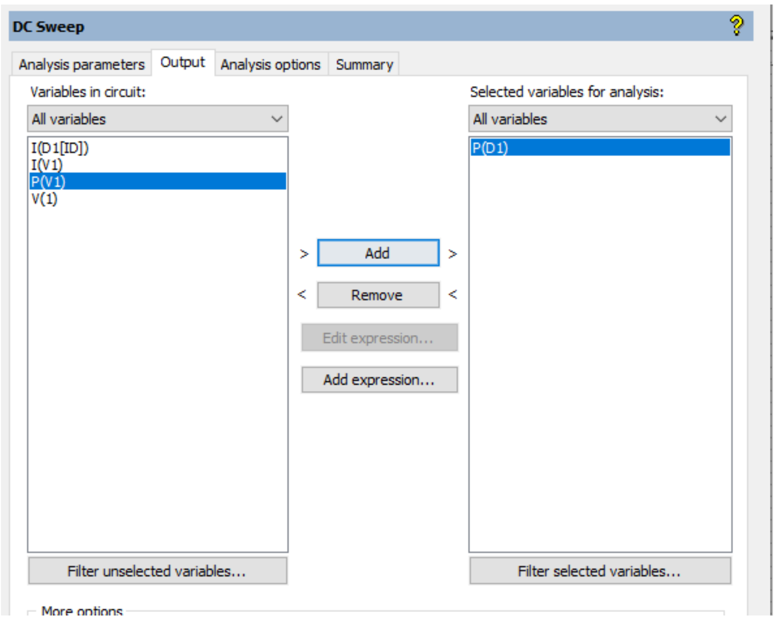


Figura 35 - Configurações de saída DC Sweep

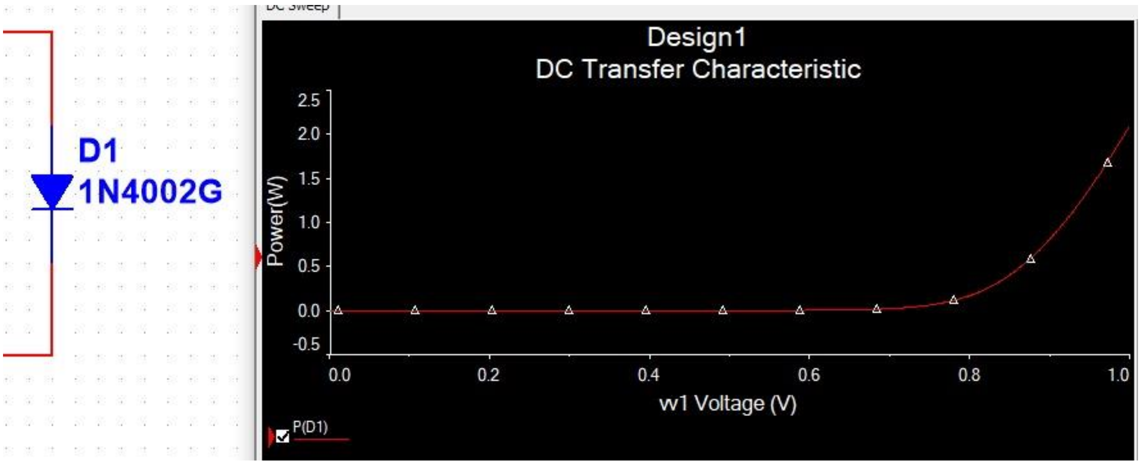


Figura 36 - Curva do diodo 1N4002G

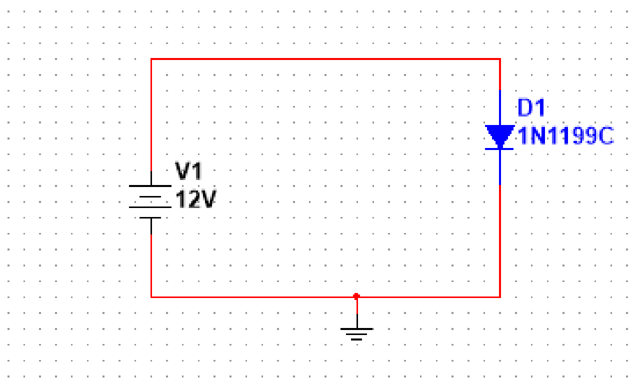


Figura 37 - Diodo número 2

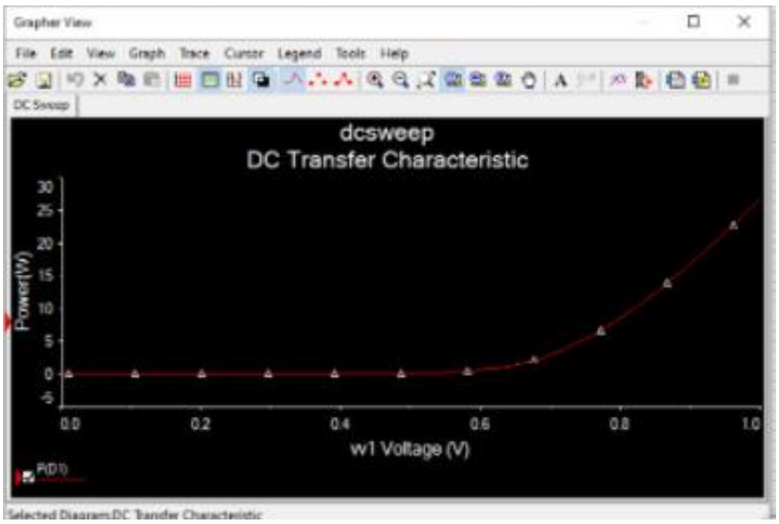


Figura 38 - Curva do diodo 1N1199C

3.3 – Diodo real X Diodo Ideal

3.3.1 – Diodo ideal

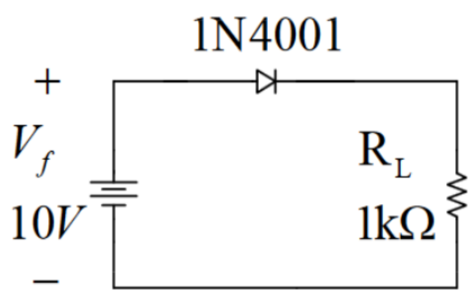


Figura 39 - Circuito 3.3.1 proposto

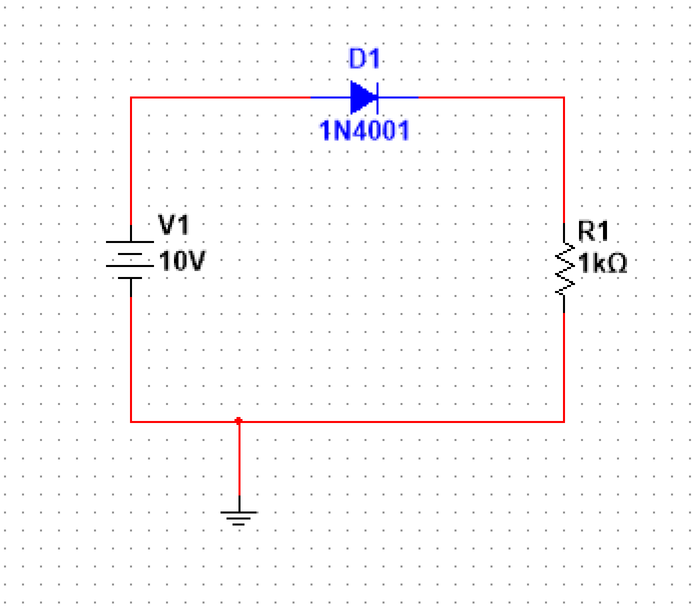


Figura 40 - Circuito 3.3.1 simulado

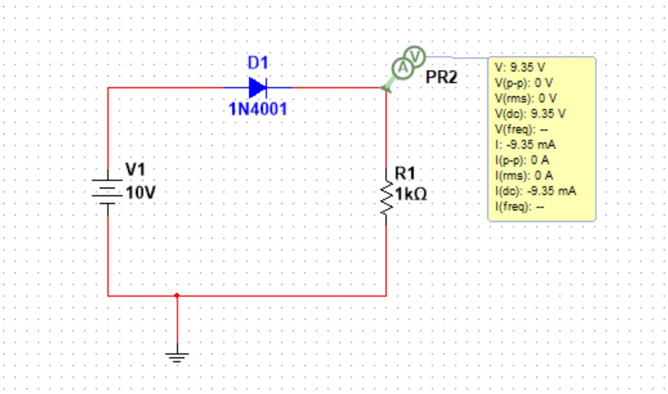


Figura 41 - Circuito 3.3.1 mensurado

CÁLCULOS

ID = 1mA VD = 0V

TABELA COMPARATIVA

PARÂMETRO	SIMULADO	TEÓRICO
ID	9,3 mA	1 mA
VD	0 V	0 V

3.3.2 Modelo simplificado

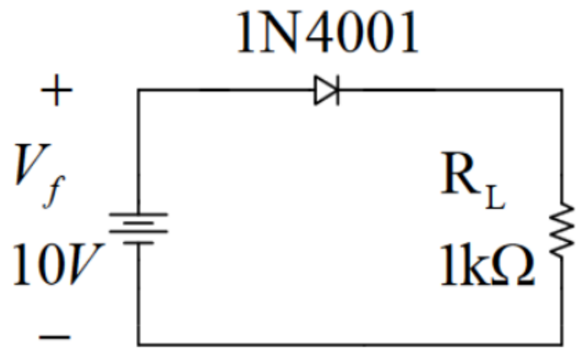


Figura 42 - Circuito 3.3.2 proposto

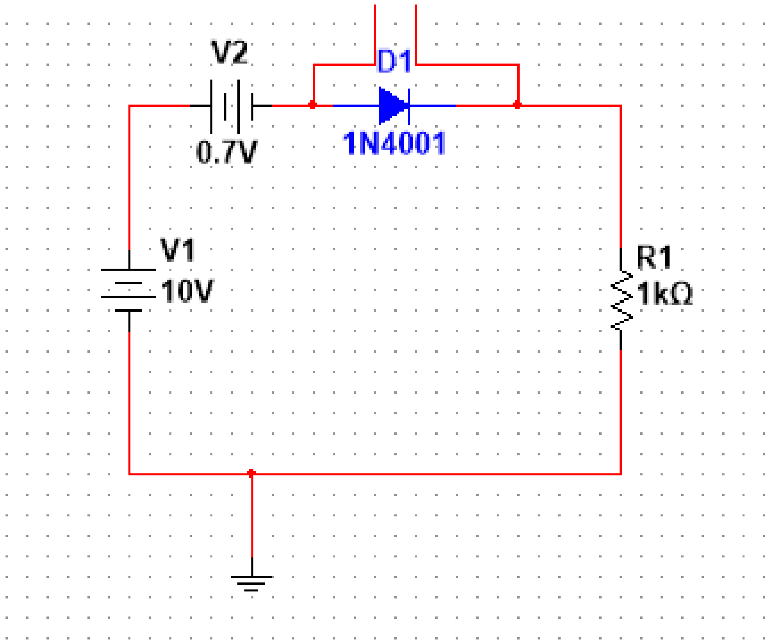


Figura 43 - Circuito 3.3.2 simulado

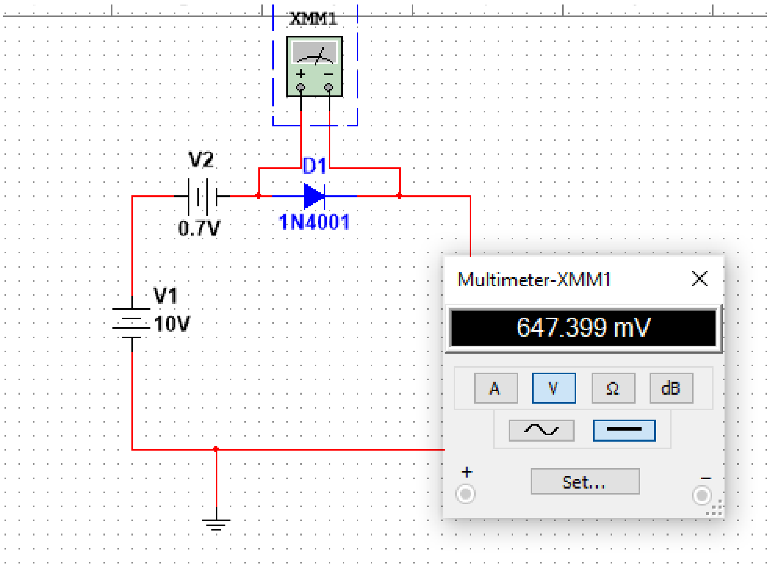


Figura 44 - Circuito 3.3.2 mensurado em VD

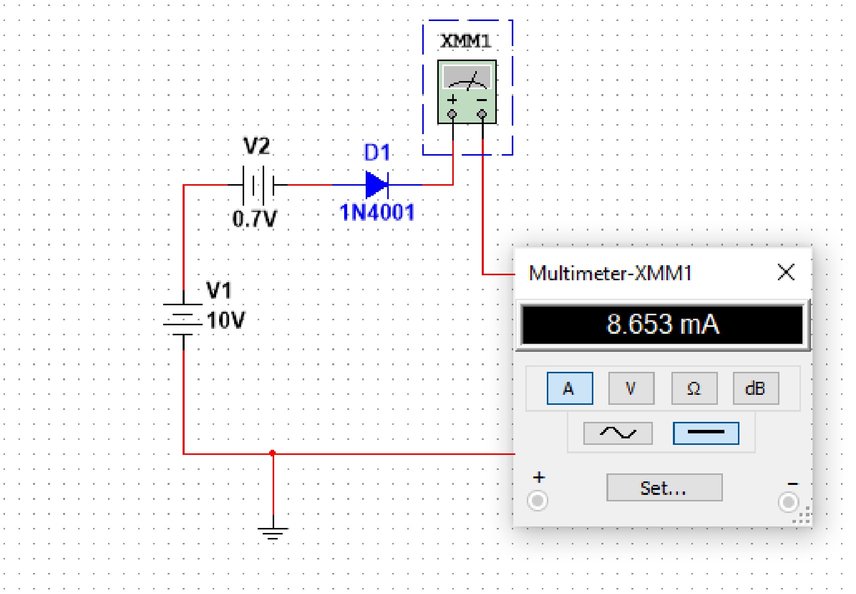


Figura 45 - Circuito 3.3.2 mensurado em ID

CÁLCULOS

$$I = V * R$$

$$ID = 10V - 0{,}7V = 9{,}3\,V \rightarrow 9{,}3 * 1k\Omega = 9{,}3\,mA$$

$$VD = 0{,}7\,V$$

TABELA COMPARATIVA

PARÂMETRO	SIMULADO	TEÓRICO
ID	8,65 mA	9,3 mA
VD	0,647 V	0,7 V

3.3.3 – Modelo linear – Considere que Ravg = 10R

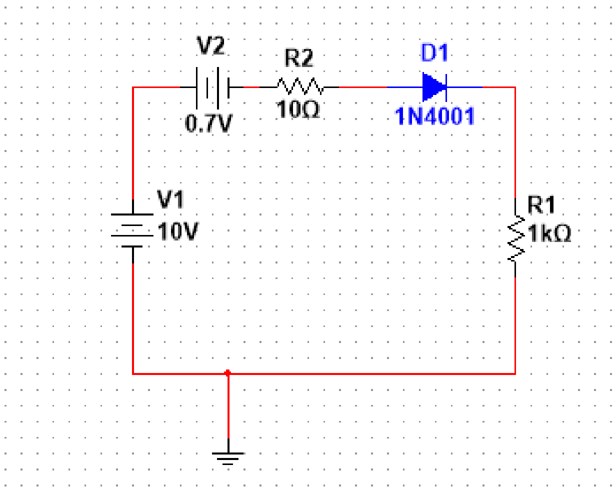


Figura 46 - Circuito 3.3.3 proposto

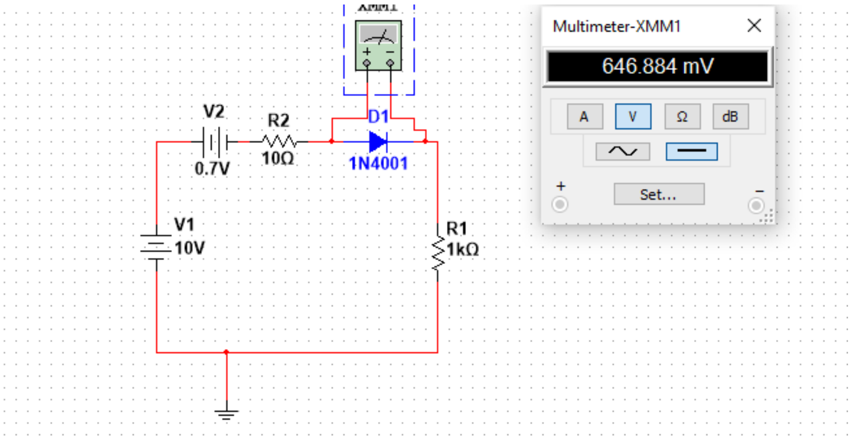


Figura 47 - Circuito 3.3.3 com VD mensurado

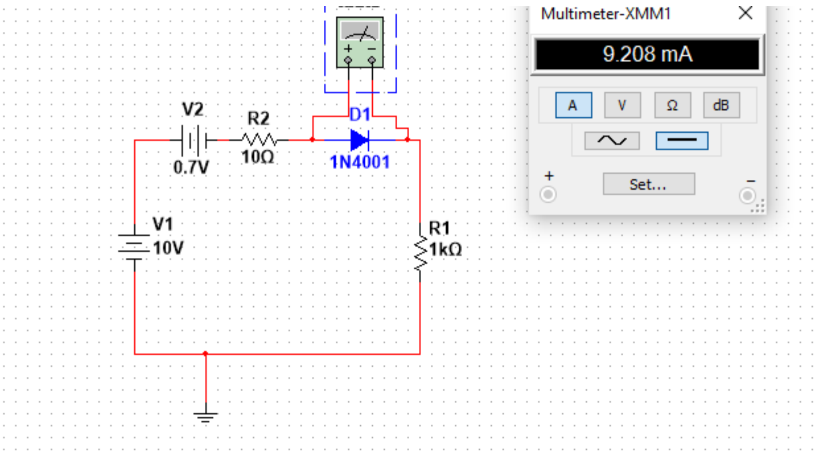


Figura 48 - Circuito 3.3.3 com ID mensurado

CÁLCULOS

$$Vf = VD + ID * Rav + ID * VL$$

$$10 = 0{,}7 + ID * (RaV + VL)$$

$$10 = 0{,}7 + ID\,(10 + 1000)$$

$$1.010\,ID = 9{,}3/1.010$$

$$ID = 9{,}2\,mA$$

$$Rmédia = 9{,}2\,mA * 10$$

$$Rmédia = 0{,}092\,\Omega$$

$$VD = 0{,}7 + 0{,}092$$

$$VD = 0{,}792\,V$$

TABELA COMPARATIVA

PARÂMETRO	SIMULADO	TEÓRICO
ID	9,2 mA	9,2 mA
VD	0,646 V	0,792 V

3.3.4 – Diodo real – Análise pela reta de carga

```python
import matplotlib.pyplot as mp
import math
IS = 1*10**(-16)
Vt = 0.025
passo = 0.001
i = 0.0
ID = []
VD = []
id = []
#CÁLCULO DE ID
while i < 0.8:
    ID.append (IS*(math.exp(i/Vt-1)))
    VD.append(i)

    i = i +passo

mp.plot(VD,ID)
mp.show()
```

Figura 49 - Programa em Python para gerar a curva do diodo e cálculo de ID

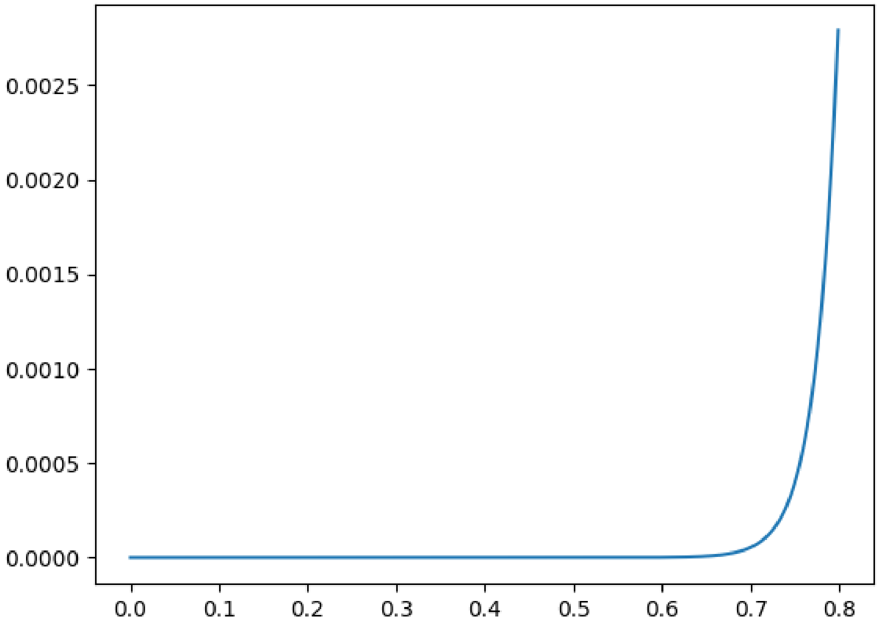


Figura 50 - Curva do diodo gerada

```python
#CÁLCULO RETA DE CARGA
Vcc = 10
rs = 2000
for pointer in range(len(VD)):
    id.append((-VD[pointer] + Vcc)/rs)

mp.plot(VD,id)
mp.show()
```

Figura 51 - Código em python para cálculo da reta da carga

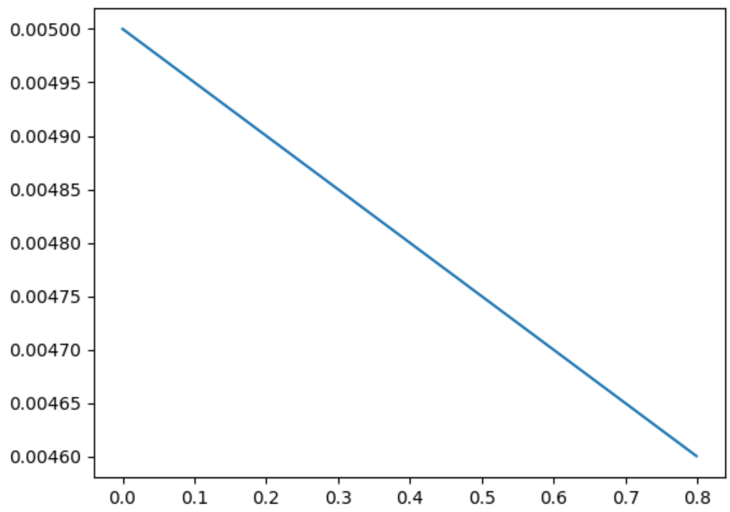


Figura 52 - Reta da carga gerada

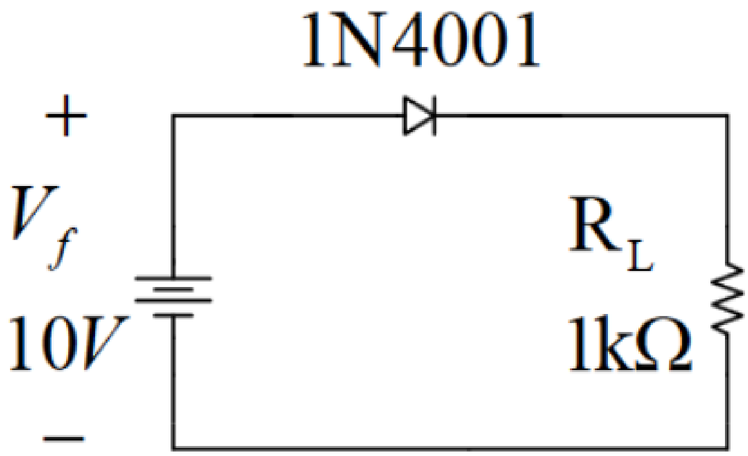


Figura 53 - Circuito proposto para a análise pela reta da carga